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Suitability of Scotch Pine Varieties for Windbreak and Urban Screen Plantings

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Suitability of Scotch Pine Varieties for Windbreak and Urban Screen Plantings

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Introduction

Each year, millions of bare-rooted seedlings, container-grown and balled-and-burlapped trees are planted as windbreaks and visual "screens" in rural and urban areas. Aesthetic qualities of species used are important; however, the ultimate tests are good survival and growth under varying site conditions.

Black or Austrian pine (*Pinus nigra*), eastern white pine (*Pinus strobus*), eastern arborvitae (*Thuja occidentalis*) and Norway spruce (*Picea abies*) are the species most commonly planted for windbreak and screen plantings in Ohio, as well as much of the central and northeastern United States. Although not extensively used for that purpose, Scotch pine (*Pinus sylvestris*) also has promise as an alternative for windbreak and screen plantings. Even though it grows best on moist, well drained sites, Scotch pine survives and grows well on sites ranging from relatively dry to moderately wet (Brown et al. 1981, Wright et al. 1966).

Scotch pine is one of the most widely distributed tree species in the world. Its native range reaches from above the Arctic Circle in the north to Spain and Turkey in the south and from Scotland in the west nearly to the Pacific Ocean in Siberia. Within this range, Scotch pine shows wide variation which has been the subject of a number of provenance studies emphasizing such traits as growth rate, stem form, needle length and color, winter injury, etc. (Wright and Baldwin 1957, Wright and Bull 1963, Wright et al. 1966, Giertych 1979). Other studies have related differences between Scotch pine seed sources in a number of other characteristics, including moisture and/or nutrient requirements (Brown 1970 and 1980), root characteristics (Brown 1969a and 1969b), insect resistance (Steiner 1974, Wright and Wilson 1972, Wright et al. 1967) and effects of timing of shearing for Christmas trees (Brown 1967).

There has been considerable discussion concerning the nature of genetic variation in Scotch pine. Where the range is discontinuous in western and southern portions of the range, changes in characteristics of trees of different seed sources are pronounced, while changes are usually more gradual in areas where the range is relatively continuous in northern and central Europe and Asia. Langlet (1959) suggested that variation is clinal, (i.e., continuous) based primarily on seedling characteristics of Swedish provenances and 17-year heights in European tests. A number of other investigators consider the pattern to be ecotypic or discontinuous. Ruby (1967) used genetic, taxonomic and climatic patterns to group different provenances into a series of 21 geographic varieties and Ruby and Wright (1976) proposed a revised classification which recognized 20 "geographic" races or varieties, plus three others which had not been described taxonomically but which were distinct enough to warrant varietal status. In this classification, a geographic variety has a distinctive geographic range and may also be termed a geographic race, geographic ecotype or portion of a cline. The geographic ranges of some isolated varieties, such as Spain or southern France, can be delimited exactly. Where varieties intergrade, as in Scandinavia and much of central Europe, boundaries can only be approximated. This classification system groups individual seed sources having relatively uniform characteristics which can be recognized in choosing material for planting for various uses.

The purpose of the studies reported here was to investigate the suitability of different seed sources and/or varieties of Scotch pine for use as windbreak and "screen" plantings.

Materials and Methods

Trees of 32 Scotch pine seed sources were evaluated to determine their suitability for windbreaks, urban screening and roadside plantings. Seeds of provenances used were obtained during the fall and winter of 1970-1971. Most seedlots were acquired from cooperators in Europe, with most consisting of seed from ten or more average trees in stands of

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several acres. Exact information was available for location of most of those stands. Some seedlots were obtained from commercial seed dealers, and for those, adequate information was available to provide the general location of each collection (Table 1).

In the spring of 1971, seeds were broadcast sown in nursery beds at the Ohio Division of Forestry's Mariettta Nursery. Routine maintenance was provided by the nursery crew until trees were lifted (2-0 stock) in the spring of 1973. Trees were outplanted on an upland and a bottomland site at the Ohio Agricultural Research and Development Center's (OARDC) Pomerene Forest Laboratory near Coshocton, Ohio, using a spacing of 8 feet between rows, 6 feet between trees within rows and

Table 1. Seed source information for Scotch pine planted at the OARDC Pomerene Forest Laboratory.

Variety[1]	Seed Source Number[2]	Country of Origin	North Latitude (°-')	East Longitude (°-')	Elevation m
Scandinavian Varieties					
Lapponica	1	Finland	63-40	25-20	135
Septentrionalis	48	Norway	59-20	08-50	105
	49	Sweden	60-53	14-21	—
	67	Finland	60-00	23-05	—
Rigensis	50	Sweden	57-39	15-33	—
Central European Varieties					
Polonica	51	Poland	53-15	20-55	120
	52	Poland	52-42	23-45	160
	54	Poland	52-48	16-03	90
Carpatica	36	Czechoslovakia	50-15	16-10	275
	37	Czechoslovakia	48-55	16-15	395-455
Vindelica	80	Austria	"Altenberg, N.O."		200-610
	81	Austria	50-46	13-45	305
Haguenensis	8[3]	Belgium	51-25	05-05	60
	59	W. Germany	50-35	09-40	—
	87	France	49-01	07-27	215
Subillyrica	90	Italy	46-45	13-18	640-790
'E. Anglia'	40[3]	England	51-30	00-07	25
Western and Southern European Varieties					
Scotia	44	Scotland	57-10	-04-50	215
Aquitana	41	France	44-44	03-49	290
	60	France	45-20	03-08	945
Iberica	4	Spain	40-07	-04-00	1495
	34	Spain	43-37	-00-20	1280
	35	Spain	40-51	-03-25	1220-1525
Romanica	69	Romania	47-38	25-20	1130
	70	Romania	45-15	26-25	730
Illyrica	83	Yugoslavia	42-52	19-25	1005-1495
Rhodopaea	38	Greece	40-15	22-01	1370
Armena	64	Turkey	31-05	39-58	1525
	86	Turkey	41-32	34-33	1130
'Nelson King'	141[4]	—	—	—	—
'Norwest'	143[4]	—	—	—	—
'Nyebranch'	144[4]	—	—	—	—

[1]Varietal names assigned to geographic areas of Scotch pine range by Rudy and Wright (1976).
[2]OARDC acquisition number.
[3]Seed purchased from commercial seed dealers.
[4]Seed collection made by commercial nurseries from planted stands in Pennsylvania.

individual provenances arranged in 4-tree linear plots within rows.

On the upland site, a completely randomized experimental design was used, with six, 4-tree replications of each provenance, and on the bottomland area a randomized complete block design with three replications was used. A single border row of trees was planted around each planting to reduce border effects and those trees were not measured. In the fall of 1981, trees in plantings were thinned to 2-tree plots, leaving an average residual spacing of 8 feet by 12 feet.

Soils on the upland site are a Dekalb loam, a moderately deep, well drained, loamy, skeletal, mixed mesic typic Dystrochrept and a Gilpin silt loam, a moderately deep, well drained, fine, loamy mixed mesic Hapudult. Topography on the area ranges from nearly level up to 25 percent slopes, with slopes having an eastern aspect. The bottomland area is nearly flat and the soil is a Fitchville silt loam, a deep, somewhat poorly drained, fine, silty, mixed mesic aeric Ochraqualf.

Evaluations of the two Scotch pine plantations were made during the summer of 1983. Total heights were measured to the nearest 0.1 feet and tree widths to the nearest 1 foot. Foliage density was estimated visually as the percentage of light blocked by foliage, limbs, etc. Trees were scored for stem form using a seven point scale (1=very poor to 7=very good) and limb configuration (amount of twisting of branches) using a five point scale (1=very contorted to 5=very straight). Scores were assigned independently for each characteristic. Width/height ratios were calculated and an "appearance index" was developed in an attempt to combine various characteristics into a single rating which would describe shape and form of trees. The equation used in this index was: Appearance Index=Stem Form Rating/7+Density Rating/100+Limb Configuration Rating/5. The divisors used with each rating give approximately equal weight to each characteristic in the system. In addition to measurements and evaluations made in 1983, winter foliage color ratings (1=yellow to 9=blue-green) made in the same plantings in January 1980 are included for comparison and discussion.

Data were analyzed by analyses of variance using individual tree measurements as items. Initially, analyses were made comparing all individual seed sources as well as combinations of individual seed sources into varietal groups assigned to geographic areas of the Scotch pine range by Ruby and Wright (1976). Initial analyses indicated that although there was considerable variation between varieties in all characteristics, data for provenances within varieties was very similar. Additionally, with the exception of heights, differences in characteristics between the two planting sites were generally minimal, with no consistent differences related to location. Therefore data for all characteristics other than height were combined for the two sites and analyzed and those results reported in the following sections. $LSD_{.05}$'s were calculated for comparing differences between means.

Results and Discussion

Although not evaluated as part of this study, previously collected data indicate that survival of trees of all Scotch pine varieties in the plantations sampled was excellent: average 9-year survival (before thinning in 1981) was over 90 percent for both the well drained upland and somewhat poorly drained bottomland sites.

In sections that follow, results are discussed primarily on the basis of differences and/or similarities between varieties, which are combined into three groups: those from the more or less continuous portion of the Scotch pine range in Scandinavia; those from the more or less continuous range in central Europe; and those from disjunct, isolated portions of the range in western and southern Europe. '*East Anglia*', from a portion of England outside the natural Scotch pine range, is believed to be a hybrid between trees of var. *scotia* and a German seed source (Ruby and Wright 1976); characteristics of those trees were more similar to the German origin and were included with the central European varieties. The American commercial seed sources had a number of characteristics similar to each other; they were also similar to some of the southern and western European varieties and were included with that group.

All analyses of variance by variety were statistically significant at the 1 percent probability level or less, except for density which was significant at the 5 percent probability level.

Height. Differences in 11-year heights (after field planting) of trees of different varieties of Scotch pine generally followed patterns outlined in earlier studies (Wright and Bull 1963, Wright et al. 1966, Giertych 1979). Trees of central European varieties were generally fastest growing, with average heights being 6 to 20 percent greater than the plantation average on the upland area and 5 to 14 percent higher on the bottom (Table 2). Trees of var. *baguenensis* were tallest, averaging 20.0 feet on the upland and 16.7 feet on the bottomland, nearly twice as tall as trees of var. *lapponica* from northern Finland (Figures 1 and 2).

Within the Scandinavian varieties, growth of trees increased with decreasing latitude. However, there were no obvious relationships to latitude or longitude for varieties from the discontinuous portions of the species range in western and southern Europe. On the upland area, total heights of individual varieties ranged from 10 percent below (var. *armena*) to 8 percent above (var. *aquitana*) the plantation average, while on the bottom, the range was from 9 percent below (var. *iberica*) to 5 percent above (var. *illyrica*).

As shown in Table 2, trees on the well drained upland site averaged nearly 16 percent taller than on the somewhat poorly drained bottomland area. However, relative growth (i.e., as a percentage of plantation means) of individual varieties changed only sightly, with differences between sites of 7 percent or less for all varieties.

Width/Height Ratios. Use of trees which are relatively wide in relation to height could form screens or windbreaks in less time or with fewer trees. Conversely, this characteristic could be beneficial in identifying relatively narrow trees for landscaping.

Width/height ratios show that trees of all Scotch pine varieties were relatively wide, averaging 77 percent as wide as tall (Table 2). Slow growing trees of var. *lapponica* had the narrowest crowns (67 percent). However, all other varieties had ratios of at least 74 percent, with the widest being trees of the fast growing central European vars. *vindelica* (84 percent) and *haguenensis* (82 percent) (Figures 1 and 2).

The wide crowns of trees should permit planting at relatively wide spacings. Pines and spruces used for windbreaks and screens are commonly planted at 10 foot spacings between rows and trees. Similar spacings should be suitable for the moderate to moderately fast growing Scotch pine varieties from southern Scandinavia and southern and western Europe. However, for the faster growing central European varieties, spacing of trees could be increased to 12 feet.

Table 2. Eleven year heights and width/height ratios for trees of Scotch pine varieties planted on two sites at the OARDC Pomerene Forest Laboratory.

Variety[1]	Total Height		Ht., % Plant. Mean		Width/Height
	Upland ft	Bottom ft	Upland %	Bottom %	Ratio %
Scandinavian Varieties					
Lapponica	10.8	8.5	65	59	67
Septentrionalis	14.1	12.8	84	88	74
Rigensis	15.8	14.1	94	100	79
Central European Varieties					
Polonica	18.7	15.1	112	105	77
Carpatica	19.0	16.4	114	114	78
Vindelica	18.4	16.1	110	111	84
Haguenensis	20.0	16.7	120	116	82
Subillyrica	17.7	15.1	106	105	77
'E. Anglia'	18.0	16.4	108	114	77
Western and Southern European Varieties					
'Commercial'	17.7	14.8	106	102	74
Scotia	16.7	14.8	99	102	74
Aquitana	18.0	14.8	108	102	79
Iberica	15.8	13.1	95	91	77
Romanica	16.1	13.4	96	93	78
Illyrica	16.4	15.1	98	105	80
Rhodopaea	15.8	14.4	95	100	81
Armena	15.1	13.8	90	95	78
Mean	16.7	14.4	100	100	77
$LSD_{.05}$	1.3	1.3	7	9	2

[1]See Table 1 for countries of origin for each variety.

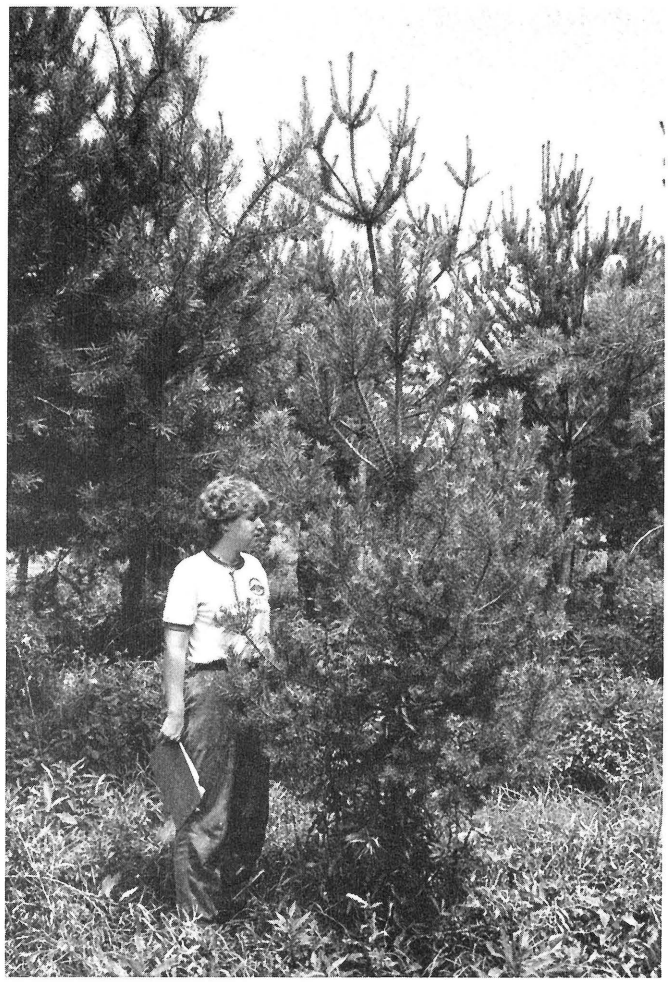

Figure 1. Tree of var. *lapponica* (Seed Source 67, Finland) having very slow growth, narrower crown, low density, and moderately straight limbs.

Figure 2. Tree of var. *haguenensis* (Seed Source 58, W. Germany) having very fast growth, wide crown, moderate density, poor stem form and "contorted" limbs.

Density. Density of trees was evaluated by estimating the amount of light blocked by foliage and other parts of trees. This characteristic reflects the ability of trees to act as windbreaks or to visually screen areas and is a function of a number of factors.

Average density of trees was relatively low, averaging 41 percent for all varieties (Table 3). It might be expected that density would be related, in part, to growth rate and distance between whorls of limbs. However, this was not the case for the different varieties of Scotch pine. Density was lowest (35 percent) for trees of var. *lapponica* from northern Finland (Figure 1) and highest for trees of var. *rigensis* from southern Sweden which had growth rates at or slightly below the plantation averages for the two planting sites. Similarly, density for some of the fast growing European varieties (Figure 2) was equal to or better than many of the slower growing trees of varieties from western and southern portions of the species range.

Stem Form. Stem form (rated on a seven point scale from 1=very poor to 7=excellent) varied considerably between varieties. As shown in Table 3, average stem form of trees was 3.9 (fair). Trees of the three Scandinavian varieties and western and southern European vars. *romanica* and *iberica* had the straightest stems, with ratings of 4.4 to 5.0, generally in the moderately good range (Figures 1 and 3). Form was moderately poor to fair (ratings of 3.2 to 4.0) for the central European varieties and the other southern and western European varieties (Figure 2).

Limb Configuration. Limb configuration, or the extent of distorted or twisted appearance of tree limbs (rated on a five point scale from 1=very contorted to 5=straight) was not as variable as

Figure 3. Tree of var. *iberica* (Seed Source 4, Spain) having a combination of growth and appearance factors that make it one of the more desirable Scotch pine varieties for planting around homes or in urban areas.

many other traits evaluated. The average for all varieties was 2.2, indicating that on the average, limbs were somewhat contorted in appearance (Table 3, Figure 2). In general, trees of the northern var. *lapponica* had the straightest limbs (Figure 1), although even for those trees ratings were only at or near the moderately straight (3.0) classification.

As a group, trees of central European varieties generally had a rather twisted appearance: most values were at or near the contorted rating (2.0), with a range of 1.3 (very contorted) for var. *haguenensis* (Figure 2) to 2.6 (moderately straight) for var. *subillyrica*. Limb configuration of trees of southern and western European varieties was quite variable: trees of var. *armena* had limbs which were among the straightest (2.8), while ratings of others ranged from 1.8 (contorted) to moderately straight (2.4).

Appearance Index. Appearance index values (as described in the "Procedures" section) can potentially vary from 0.35 to 3.00; height, width/height ratios and winter foliage color are not included in this index, but should also be considered in selecting desirable varieties or seed sources.

The average appearance index of 1.41 (Table 3) was less than half the maximum possible in the rating system, indicating that, in general, appearance was not particularly outstanding (if straight stems and limbs and dense crowns are desired). Trees of the three Scandinavian varieties had the best indices (1.55 to 1.67); central European vars. *subillyrica* (1.50) and '*E. Anglia*' (1.44), as well as several of the southern and western European varieties also had ratings between 1.4 and 1.5 (Figure 3). Appearance indices of trees was particularly poor for var. *haguenensis* (1.29) and the commercial sources (1.18), followed by several other central, southern and western European varieties with ratings below 1.3 (Figure 2).

Winter Foliage Color. Summer foliage colors of trees of different Scotch pine seed sources/varieties are generally green to blue-green. However, there is wide variation in winter coloration. For that reason, foliage color evaluations made in the winter of 1980 are included with the data collected in 1983 because that characteristic could also be important in selecting varieties/seed sources for planting, particularly as urban screens.

For the plantations used in this study, winter foliage color of trees generally followed trends outlined in previous studies (Wright and Bull 1963, King 1964, Wright et al. 1966, Ruby 1967). As shown in Table 3, trees showed extreme variation, ranging from 1.3 (near the yellow rating) for var. *lapponica* from northern Finland to 8.0 (green to blue-green) for var. *iberica* from Spain. For varieties from the more or less continuous range in Scandinavia and central Europe, trees became progressively more green as latitude decreased, reaching a maximum of 5.9 (yellow-green to green) for var. *haguenensis*. There were two major exceptions to this trend: needles of trees of var. *subillyrica* (Italy) had a rating of 5.4 (yellow-green), and those of var. '*E. Anglia*' (thought to be a hybrid between var. *scotia* and a German origin) had a foliage rating of 6.5 (green) which was more similar to var. *scotia.*

Trees of varieties from isolated, disjunct portions of the species range in western and southern Europe generally had good winter foliage color, with vars. *iberica* (8.0) and *aquitana* (7.7) having green to

Table 3. Visual characteristics of trees of Scotch pine varieties planted on two sites at the OARDC Pomerene Forest Laboratory.

Variety[1]	Density %	Stem Form Rating[2]	Limb Config. Rating[3]	Appear. Index Rating[4]	Winter Foliage Color[5]
Scandinavian Varieties					
Lapponica	35	5.0	3.0	1.65	1.3
Septentrionalis	40	4.4	2.6	1.55	2.2
Rigensis	48	4.4	2.1	1.67	2.5
Central European Varieties					
Polonica	41	3.6	1.8	1.28	3.9
Carpatica	44	3.3	1.9	1.27	4.5
Vindelica	45	3.4	1.7	1.29	5.2
Haguenensis	43	3.4	1.3	1.19	5.9
Subillyrica	41	4.0	2.6	1.50	5.4
'E. Anglia'	41	4.0	2.3	1.44	6.5
Western and Southern European Varieties					
'Commercial'	36	3.2	1.8	1.18	6.7
Scotia	42	3.6	2.1	1.35	6.8
Aquitana	38	3.4	1.8	1.23	7.7
Iberica	39	4.4	2.4	1.50	8.0
Romanica	38	4.4	2.2	1.45	4.6
Illyrica	39	4.0	2.2	1.40	5.8
Rhodopaea	44	4.0	2.3	1.46	6.7
Armena	40	4.0	2.8	1.53	6.9
Mean	41	3.9	2.2	1.41	5.3
$LDS_{.05}$	10	0.6	0.6	0.08	0.7

[1]See Table 1 for countries of origin for each variety.
[2]Stem Form: 1=very poor, 2=poor, 3=mod. poor, 4=fair, 5=mod. good, 6=good, 7=excellent.
[3]Limb Configuration Rating: 1=very contorted, 2=contorted, 3=mod. straight, 4=straight, 5=very straight.
[4]Appearance Rating Index=(Stem Form/7)+(Density/100)+Limb. Config./5) (Possible range from 0.35 to 3.00)
[5]Winter Foliage Color: 1=yellow, 3=greenish-yellow, 5=yellowish-green, 7=green, 9=blue green.

blue-green foliage. There were also two exceptions in this group: trees of vars. *illyrica* (5.8, yellow-green to green) and *romanica* (4.6, yellow-green) had foliage colors similar to trees of central European varieties, possibly reflecting an earlier geologic period when the range was continuous in those areas.

Suitability Ratings. In previous discussions, individual growth and visual characteristics of trees were discussed. However, it is the composite of those characteristics that would determine the suitability of trees. Table 4 presents our evaluations of suitability of the different varieties of Scotch pine for use as windbreaks and screen plantings. Although these ratings are based primarily on data presented, they also include our subjective perceptions, particularly on whether trees of some varieties might be acceptable around homes or in urban settings.

As indicated in Table 4, with the exception of var. *lapponica* from northern Scandinavia, trees of the varieties of Scotch pine evaluated have either limited or moderate suitability for use as windbreaks. Acceptability for use as screens around homes or in urban areas would be more limited. None of the varieties were rated as suited for this purpose and only vars. *iberica* (Spain), *rhodopaea* (Greece), *armena* (Turkey) and '*E. anglia*' were rated as being moderately suitable.

Conclusions

Although visual characteristics of Scotch pine may not be as desirable as those of some other species used for windbreak and screen plantings, results of this study indicate that it could be used more extensively for those purposes, particularly in

Table 4. Suitabillity of Scotch pine varieties for windbreak and urban screen plantings.

Variety[1]	Suitability for[2] Wndbrks	Urban Screens	Comments: Limiting and/or Favorable Characters
Scandinavian Varieties			
Lapponica	U	U	v. slow growth; v. poor color; mod. good appear.
Septentrionalis	L	U	slow growth; poor color; fair appear.
Rigensis	M	U	mod. growth; poor color; mod. good appear.
Central European Varieties			
Polonica	L	U	fast growth; mod. poor color; poor appear.
Carpatica	L	U	fast growth; fair color; poor appear.
Vindelica	L	U	fast growth; mod. good color; poor appear.
Haguenensis	L	U	v. fast growth; good color; v. poor appear.
Subillyrica	M	L	mod. fast growth; mod. good color; fair appear.
'E. Anglia'	M	M	fast growth; v. good color; mod. poor appear.
Western and Southern European Varieties			
'Commercial'	L	U	mod. fast growth; v. good color; v. poor appear.
Scotia	M	L	mod. fast growth; v. good color; mod. poor appear.
Aquitana	M	L	mod. fast growth; exc. color; poor appear.
Iberica	M	M	mod. growth; exc. color; fair appear.
Romanica	L	U	mod. growth; fair color; mod. poor appear.
Illyrica	M	L	mod. fast growth; good color; mod. poor appear.
Rhodopaea	M	M	mod. fast growth; v. good color; fair appear.
Armena	M	M	mod. growth; v. good color; fair appear.

[1]See Table 1 for countries of origin for each variety.
[2]Suitability Ratings: U=unsuitable; L=limited suitability; M=moderately suitable.

non-urban settings. Survival of trees was excellent on both well drained and somewhat poorly drained sites and growth of most varieties is probably equal to or greater than that of some of the other species more commonly planted for windbreaks and screens. Additionally, nutrient requirements are relatively low and fertilization would not be needed to maintain the species on most sites.

Of those varieties tested, trees of vars. *rhodopaea* (Greece), *armena* (Turkey), *iberica* (Spain) and '*E. Anglia*' would be most suitable for urban screen plantings, while trees of several of the central and southern European varieties might be used as windbreaks where good growth and survival are needed but visual appearance might not be as important.

Many of the varieties which would be most acceptable for use as both windbreak and screen plantings are also ones which are commonly planted for Christmas trees, and nursery stock and balled trees should be readily available. Although trees of the faster growing central European varieties are not as commonly planted in the United States, seed is readily available from commercial dealers.

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